LAGR Mobile Platform: Software and Hardware

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DARPA Mobile Platforms

LAGR

LAGR / UPI

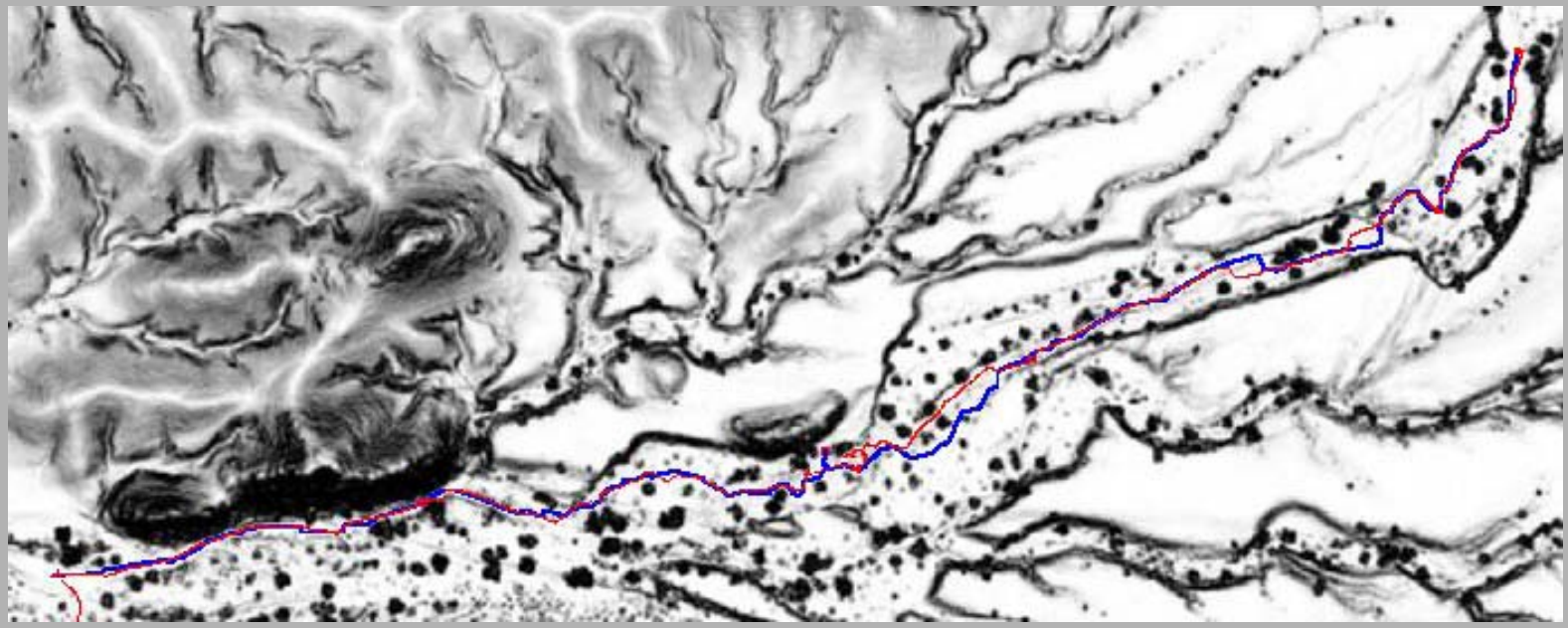
PerceptOR

LAGR Platform

Spinner

UPI

DARPA PerceptOR Program



Terrain Complexity

Easy → **Hard**

Obstacle type	• Large, rigid positive obstacles: trees, rocks, buildings • Up slopes	• Large negative obstacles: ledges, ravines • Down slopes	• Small positive and negative obstacles: thin trees, poles, chain link fences, holes, ruts, ditches	• Entanglement hazards: wire, vine, bramble, branches • Tire hazards: sharp rocks, rebar, glass	• Surface hazards: deep water, mud, ice, oily road • Dynamic hazards: people, machines
Back-ground type	• Flat, rigid, high-traction ground with no/low vegetation	• Vegetation sparse enough to avoid	• Vegetation too dense to avoid	• Thick vegetation hiding obstacles	
Viewing Conditions	• Diffuse daylight • Clear air	• Light smoke, dust, fog, rain, snow in air •Uneven illumination	• Heavy smoke, dust, fog, rain, snow in the air • Passive night		
Uncertainty	• Completely known— exact path traversed before	• Terrain type is known, such as swamp, mountain, desert, jungle	• Completely unknown		

Component Technologies

Perception

Decreasing hazard detection fidelity

Proximal:
- body collision
- near tipover
- other boo boos

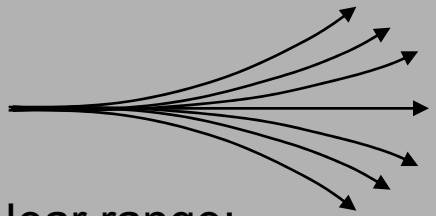
Near range:
- reliable hazard detection
- out to braking distance

Mid range:
- heuristic guidance
- based on contextual information
- out to sensor range

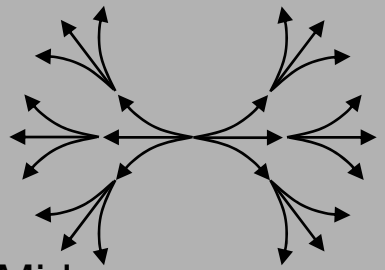
10 m

Planning

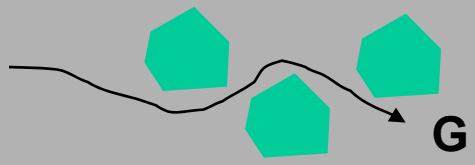
Decreasing vehicle modeling fidelity



Near range:
- kinematics (steer, body)
- dynamics (steer, brake, body)
- tire/soil interaction
- out to braking distance



Mid range:
- kinematics (steer, body)
- possibly beyond sensor range



Far range:
- kinematics (body)
- path metrics and constraints
- out to way point

Geometric Perception

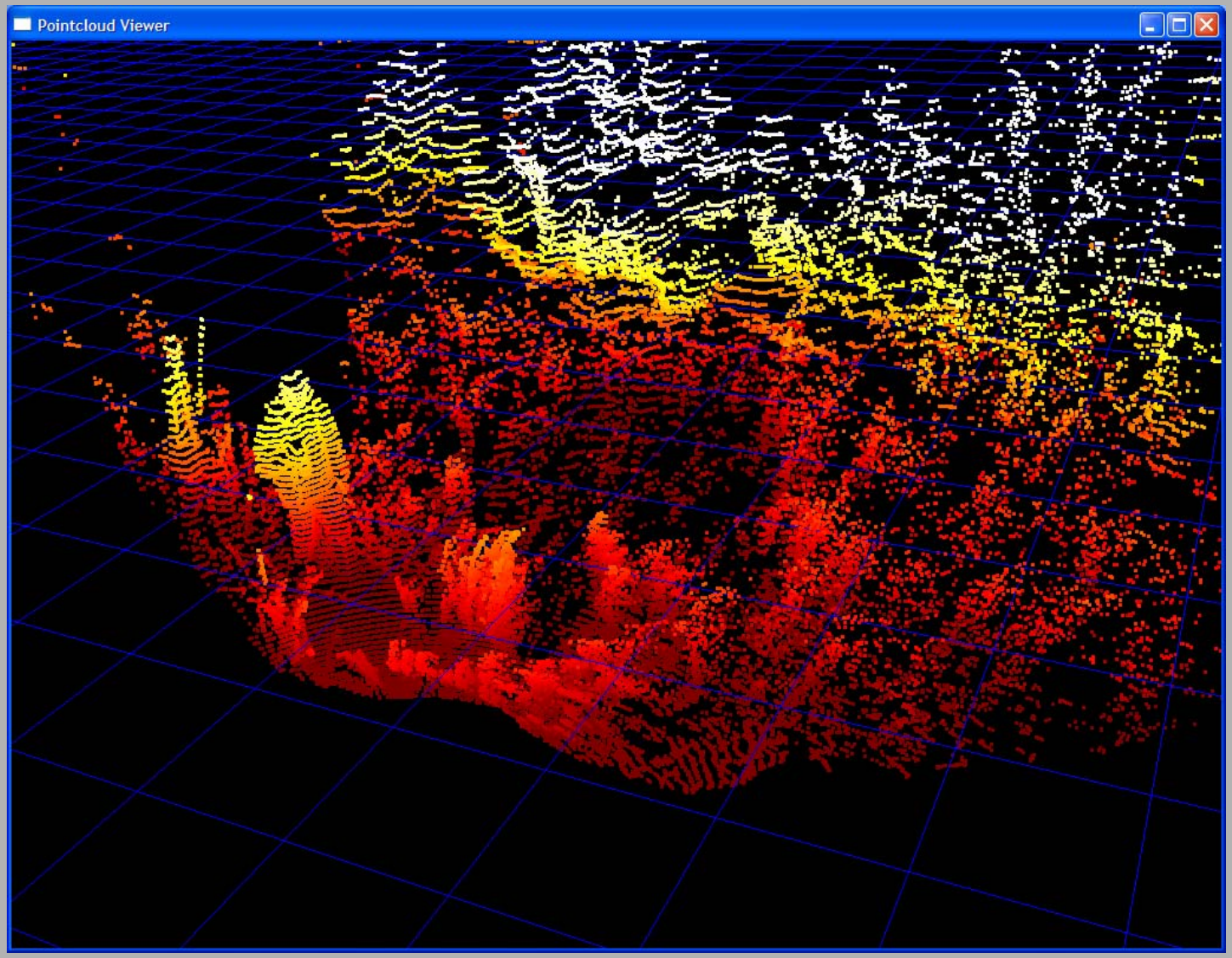
The “easy” 80% of perception is reasoning about rigid, large-scale geometric shape.

Two primary geometric sensors:

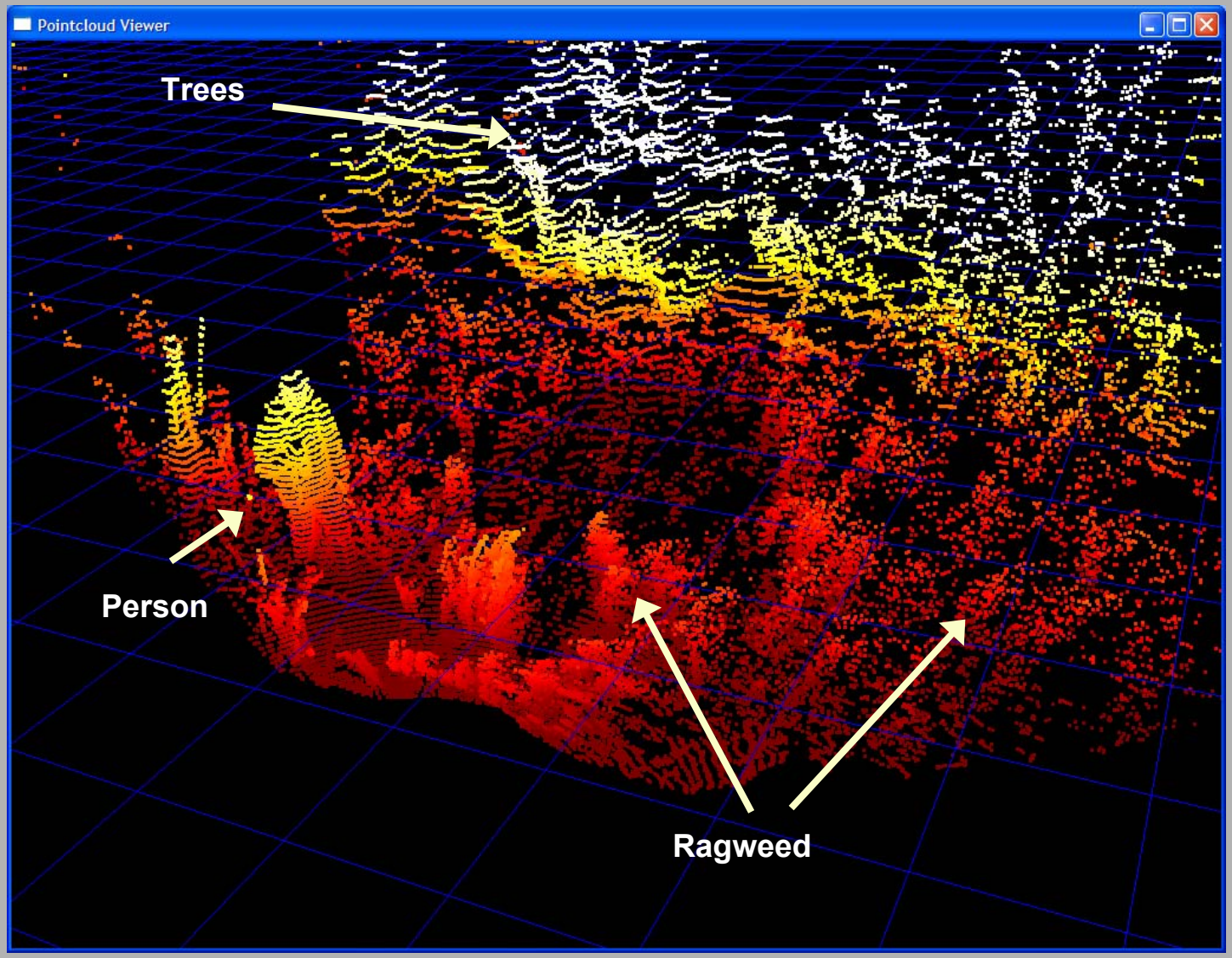
Stereo vision cameras

Ladar

Ladar-Based Geometric Analysis

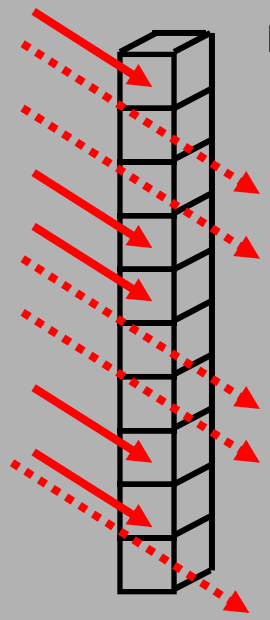


Ladar-Based Geometric Analysis

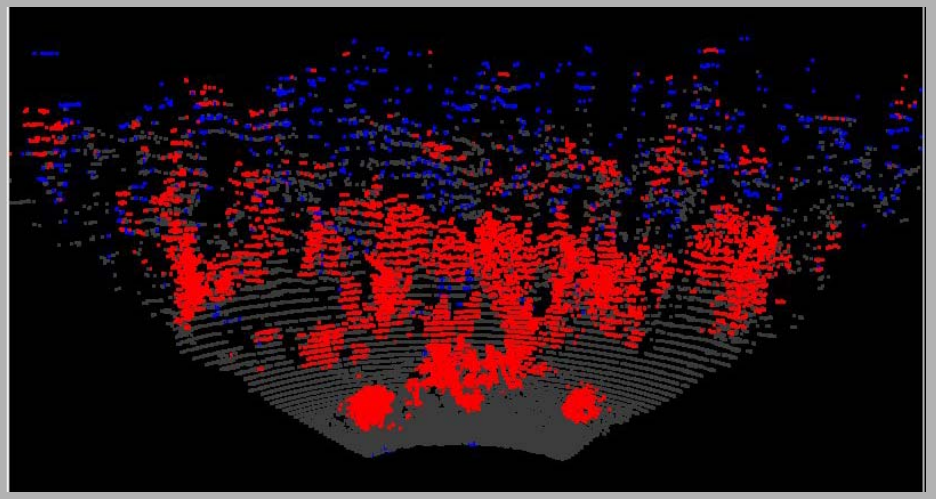


Penetrability Analysis

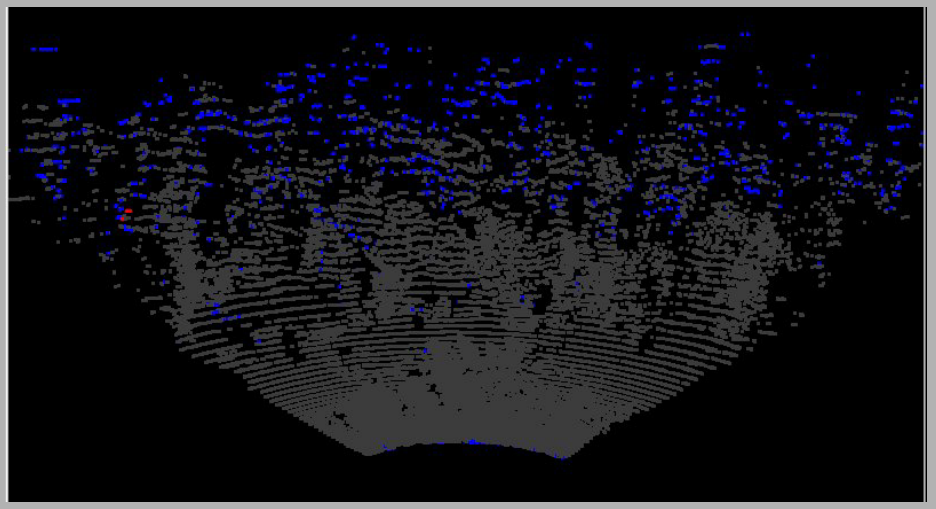
Raw camera image



Red = hazard
Blue = unknown
Grey = non-hazard

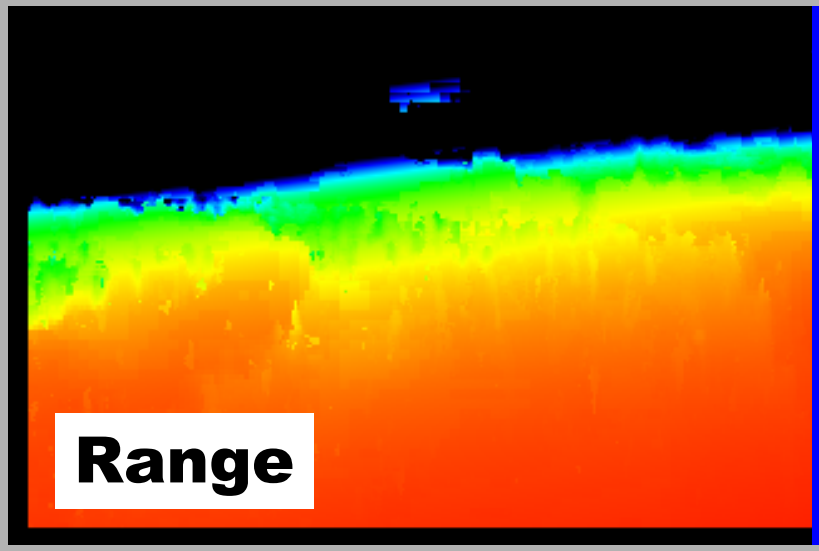


Obstacle classification due to geometry from ladar

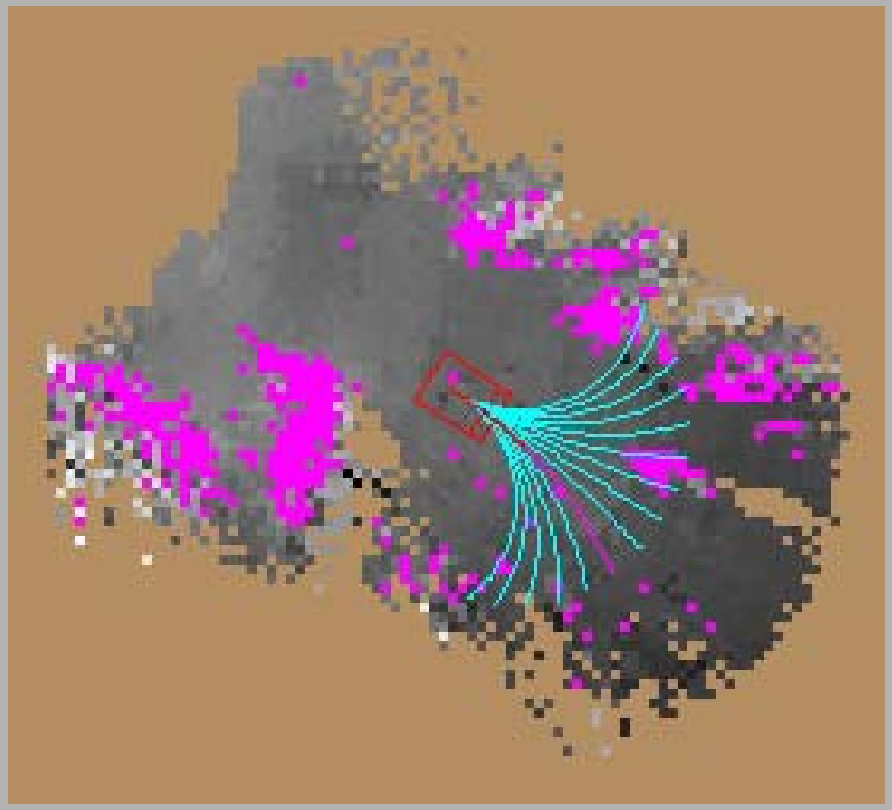


Obstacle classification due to compressibility and penetrability analysis

Stereo-Based Geometric Analysis



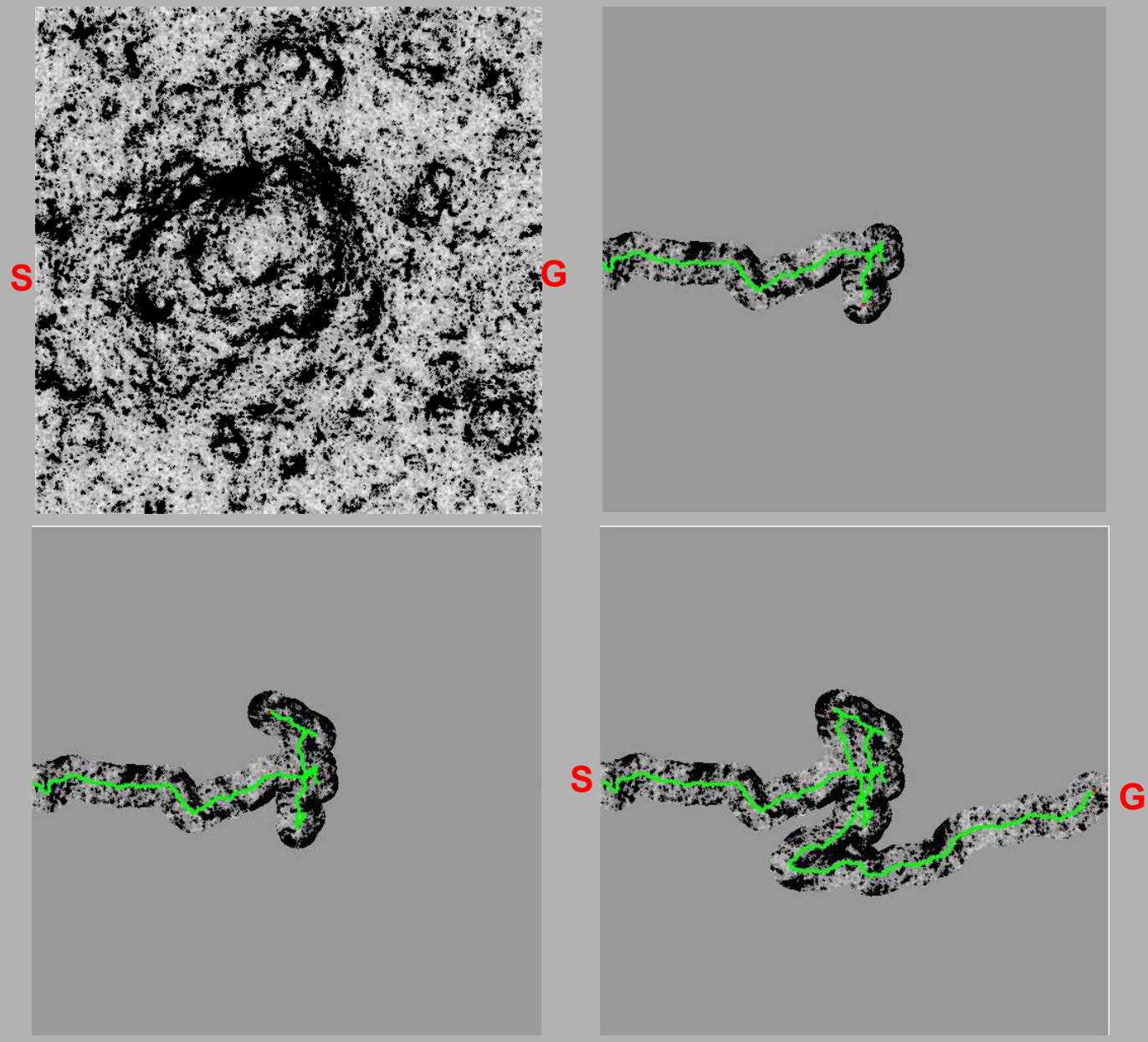
RANGER: Near Range Planning



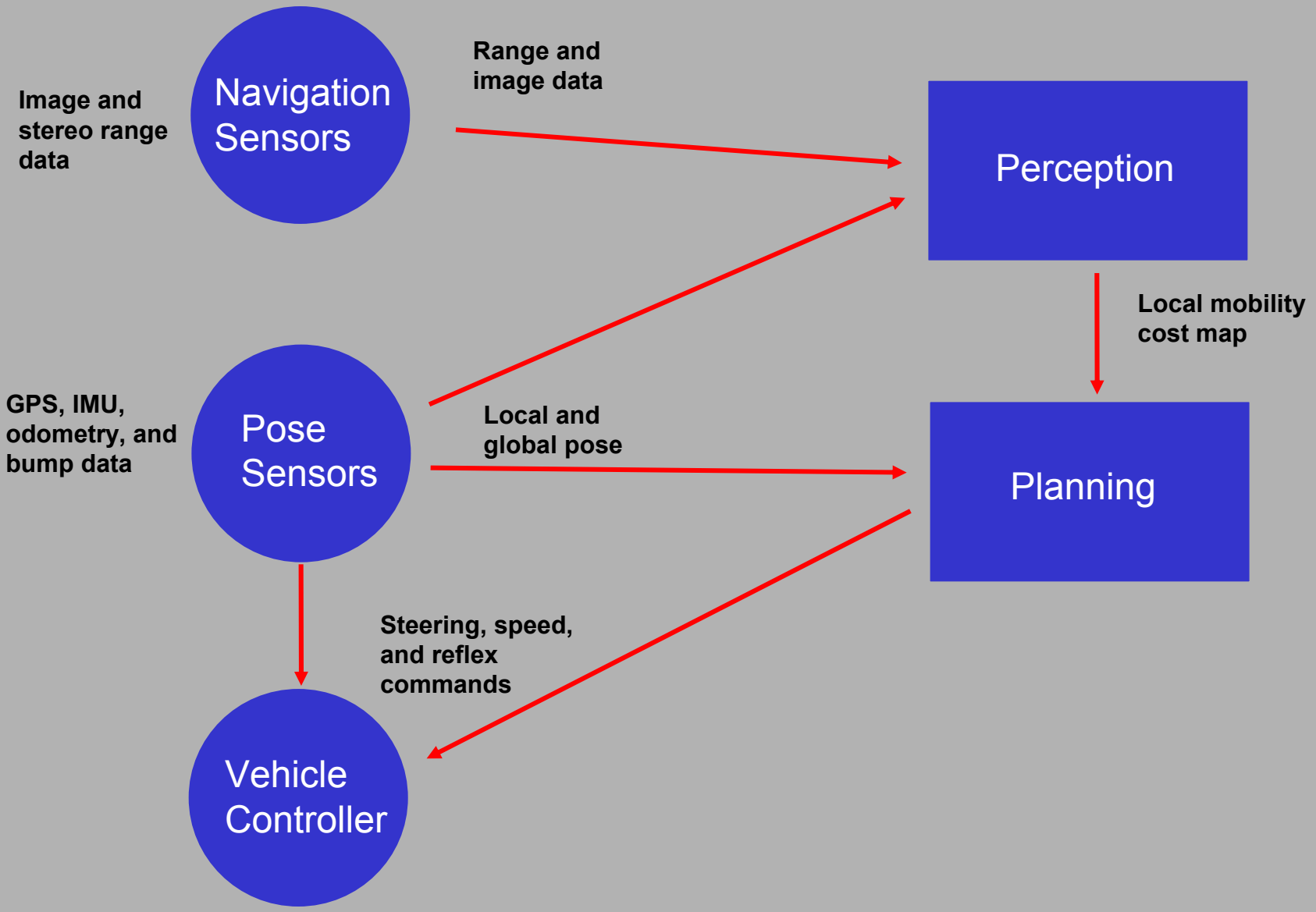
Black = low cost
White = high cost
Pink = lethal cost

RANGER local navigator:
- steering dynamics
- speed adjustments
- body collision hazard
- tip over hazard
- high centering hazard
- discrete obstacle hazards

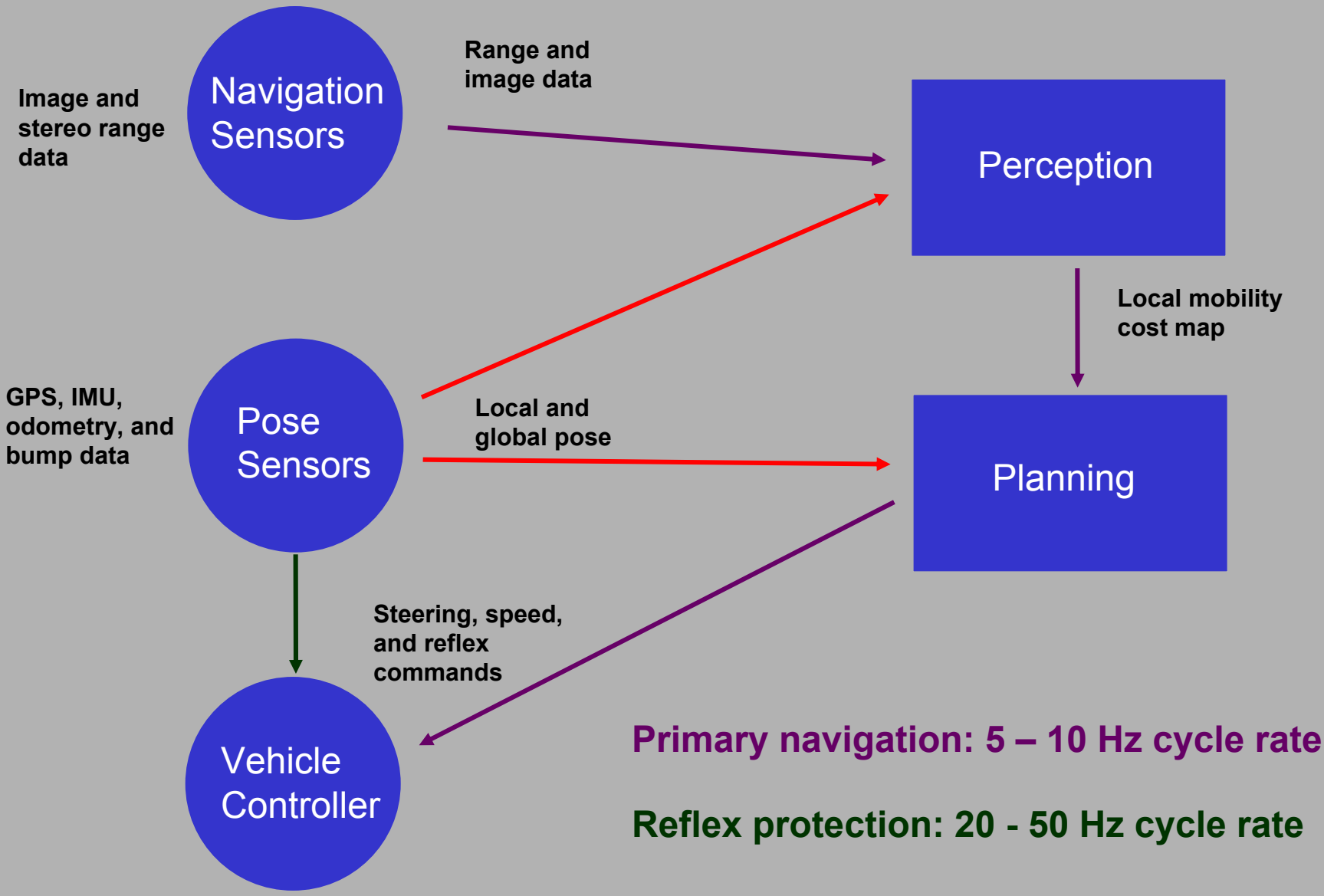
D*: Far Range Planning



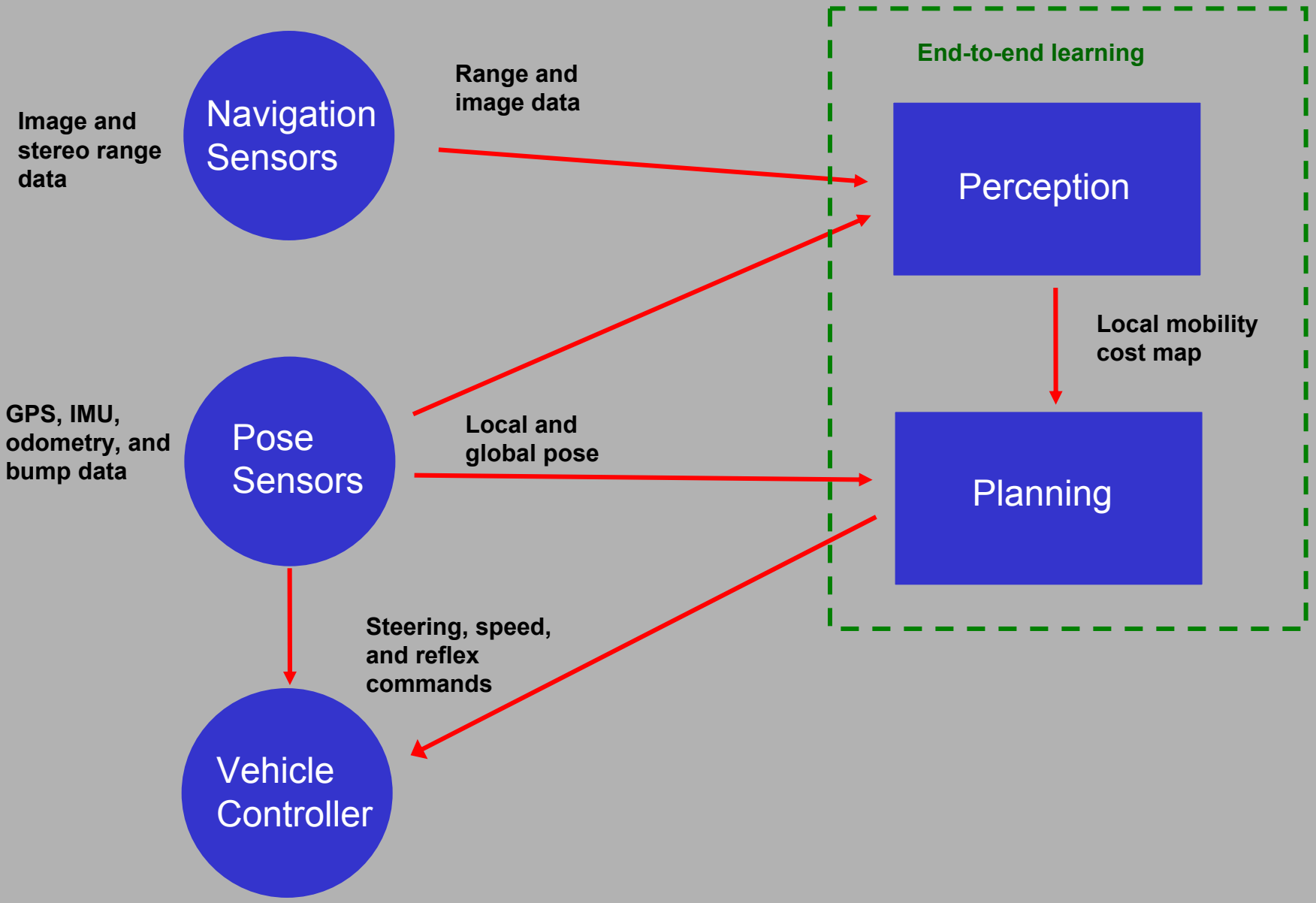
LAGR Software Architecture



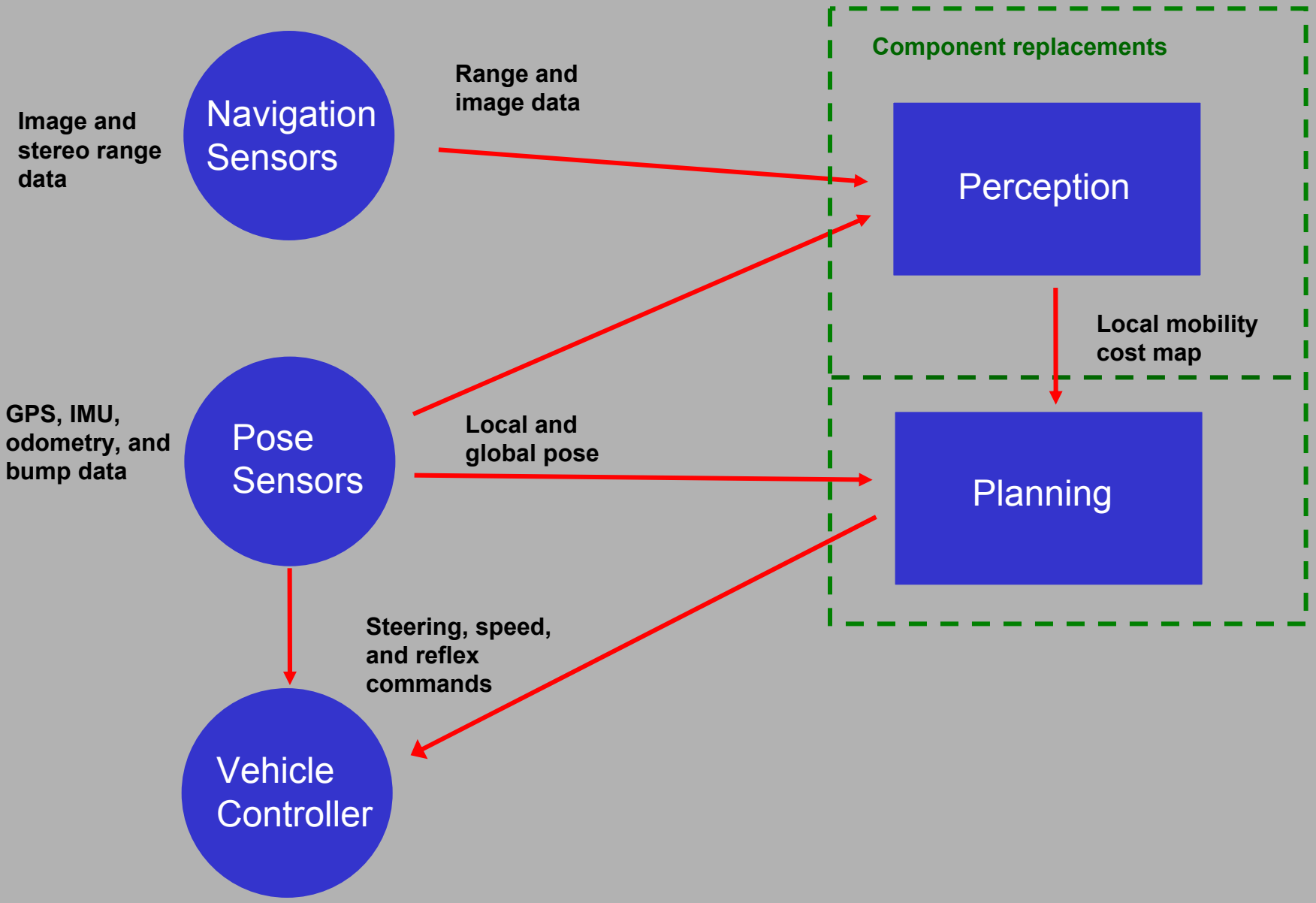
Control Loops



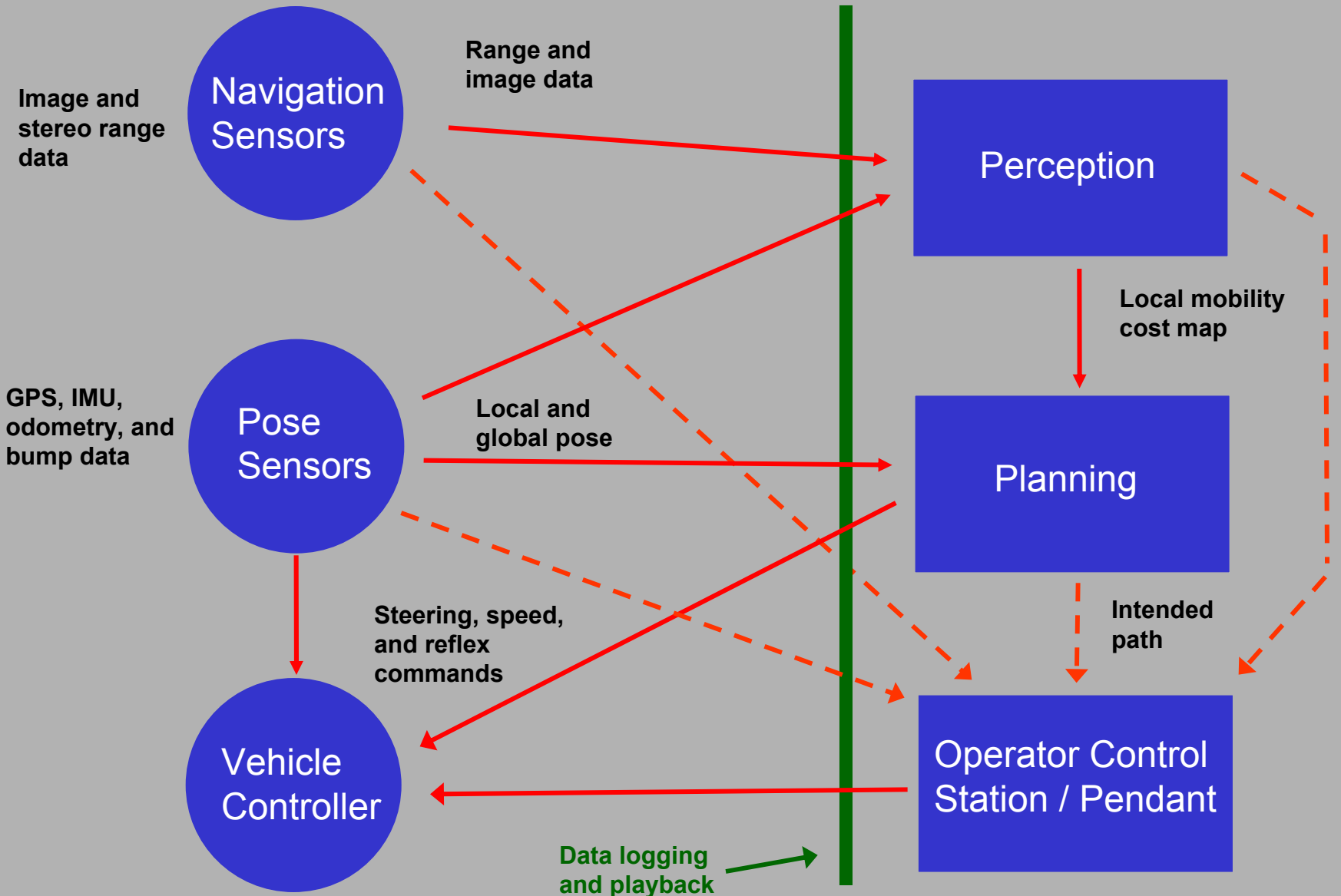
Autonomy Configurations



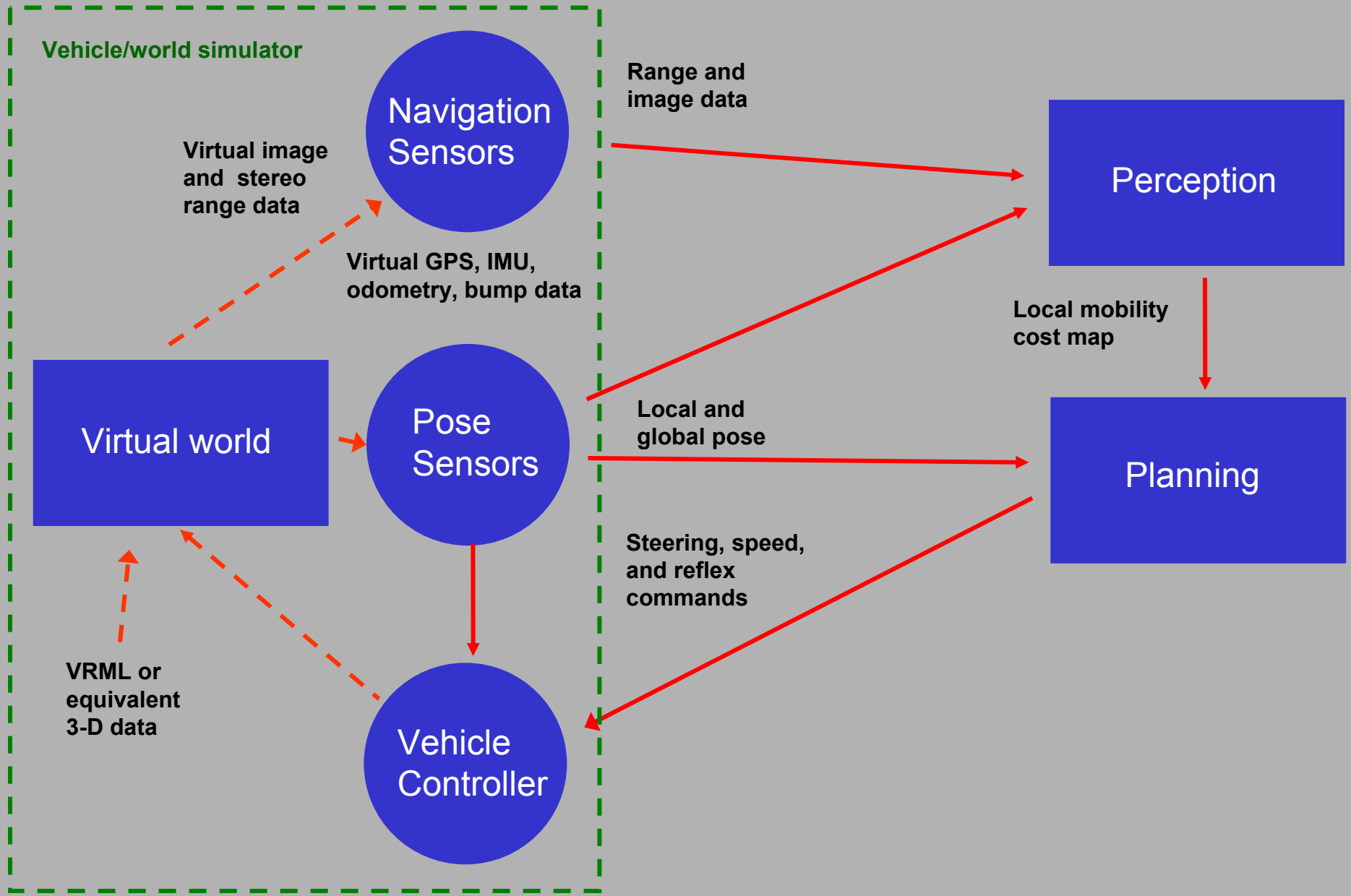
Autonomy Configurations



Operator Control & Data Logging Configuration



Simulation Configuration



API Description

- **Navigation sensors:**
  - Raw camera images
  - Stereo range maps
- **Pose sensors:**
  - Raw GPS, IMU, odometry, bump data
  - Filtered local pose (all but GPS)
  - Filtered global pose (all including GPS)
- **Vehicle control:**
  - Turning curvature
  - Speed (positive or negative)
  - Reflex control
- **Local cost map:**
  - Local cell cost data
  - Local cell elevation data
  - Fusion rule (max, min, avg)

OCS + Video Display